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Environment, Safety, and Health

Volume II

Part 12: General H&S Controls—Safety Equipment and Facilities

Document 12.1
Access Control, Safety Signs, Safety Interlocks, and Alarm Systems

Recommended for approval by the ES&H Working Group

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12.1

Access Control, Safety Signs, Safety Interlocks, and Alarm Systems*

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Access Control, Safety Signs, Safety Interlocks, and Alarm Systems

1.0 Introduction

This document contains requirements for the design, selection, maintenance, and operation of access control systems and alarm systems. Access control systems include signs, lights, barricades or barriers, audible warning devices, safety interlock systems, lock-controlled master switches, and run/safe boxes. These systems control access to potentially hazardous areas. Alarm systems warn of potential or actual degradation in the safety of an area or operation.

Appendix A of this document contains terms and definitions used in this document. Appendix B contains signs used to warn of potential hazards that may be present in LLNL operations.

2.0 Hazards

LLNL activities involve the use of potentially hazardous materials (e.g., radioactive materials and high explosives) and equipment (e.g., lasers and accelerators). Failure to control access while potential hazards exist or to warn workers of degradation in the safety of an area could result in personnel injury or damage to Laboratory property.

3.0 Reliability Requirements for Access Control and Alarm Systems

Because of their importance to safety, access control systems and alarms systems must have high reliability. As part of the hazard assessment process described in Document 2.2, "Managing ES&H for LLNL Work," in the *Environment, Safety and Health (ES&H) Manua*l, responsible planners and designers shall develop reliability requirements for specific systems before designing or selecting the necessary hardware. Fire Alarm and Emergency Voice Alarm Systems are required to meet the National Fire Alarm Code, NFPA 72.

3.1 Single Point Failures

Whenever possible, access control and alarm systems are to be designed to prevent single point failures from negating the ability of such systems to perform safety functions as intended. For example, safety interlocks on accelerator cave doors are installed in pairs and in series so that the failure of one of the interlocks in an unsafe position will not result in an unsafe condition.

3.2 Tamper Resistance

Access control and alarm systems shall be designed to minimize the potential for unauthorized or inadvertent changes to safety equipment and wiring. Possible methods include locking interlock enclosures, installing wiring in conduit or otherwise acceptable tamper-resistant wireways, and using screw covers or lockable enclosures.

3.3 Fail-Safe Design

Access control and alarm systems and their components shall be designed whenever possible such that the loss of power or the failure of any component will most likely result in a safe condition. For example, the most likely failure mode for an interlock should be in the open (shut the system down) rather than the closed position (system operational). Fire Alarm and Emergency Voice Alarm Systems are required to meet the National Fire Alarm Code, NFPA 72.

4.0 Selection of Access Control Systems

The level of sophistication required for access control systems is based on the potential hazard. The greater the potential hazard, the greater the need for effective access control. Specific requirements for signs, alarms, access control, and interlock equipment can be found in the following documents in Volume II of the *ES&H Manual:*

Radiological activities

- Document 20.1, "Occupational Radiation Protection," in the *ES&H Manual*.
- Document 20.5, "Occupational Radiation Protection: Implementation of 10 CFR 835," in the *ES&H Manual*.
- Document 20.3, "LLNL Radiological Safety Program for Radiation-Generating Devices," in the *ES&H Manual*.

Chemical and Biological hazards

- Document 10.2, "LLNL Health Hazard Communication Program," in the *ES&H Manual*.
- Various sections of Part 13, "Biological"; Part 14, "Chemical"; and Part 18, "Pressure/Noise/Hazardous Atmospheres", in the *ES&H Manual*.

Lasers, high-power microwave devices, and other physical agents and hazards

- Document 20.8, "Lasers," in the *ES&H Manual*.
- Document 20.7, "Nonionizing Radiation and Fields (Electromagnetic Fields and Radiation with Frequencies Below 300 GHz)," in the *ES&H Manual*.
- Document 18.6, "Hearing Conservation," in the *ES&H Manual*.
- Document 16.1, "Electrical Safety," in the *ES&H Manual*.

Explosives

- Document 17.1, "Explosives," in the *ES&H Manual*.
- Document 21.4, "Shipping Explosives Offsite," in the *ES&H Manual*.

DOE M 440.1-1, *DOE Explosives Safety Manual*, also contains additional requirements pertaining to signs, alarms, and access control systems when handling and storing explosives.

Table 1 contains general guidance for selecting access control systems for work areas that are not covered in the documents above. The selection is based on the severity of the hazard(s) that may be present in the area, with controls increasing rigorously as the potential hazard(s) increase. Specific access controls for a particular area or operation will depend on the potential hazards and equipment configuration. Contact your ES&H Team for assistance with the proper selection of access controls.

Table 1. General guidance for the selection of access control systems.

Potential Hazard	Typical Access Controls
Injury is possible, but hazards are readily apparent, well contained, or identified.	• Signs • Barriers
Serious injury is possible if the enclosure is breached during operation.	As above, and: • Interlocked enclosures • Warning lights or alarms • Locked entryways • Safety plan
Significant, immediate hazard exists that could cause serious injury or death if workers enter or remain inside the enclosure during any operating modes.	As above, and: • Run/safe safety boxes • Key-interlock switches on the control console • Key-controlled master switch • Continuous direct or electronic surveillance that is capable of preventing unauthorized entry

5.0 Safety Signs

Any area where a person needs to take action or added caution because a hazard exists shall be posted with a safety sign regarding the hazard and the required actions. Other access controls may be installed as additional safeguards.

5.1 Format

To ensure uniform response by workers, safety signs should be of the same type for similar hazards. Signs mounted on poles should be a minimum of 7 ft above ground level. The format for traffic signs should be in accordance with the requirements of the Uniform Traffic Control Devices Code. The format for other safety signs shall be the appropriate color, where specified, and include the information in Appendix B.

5.2 Types of Signs

The signs described below and shown in Appendix B are used at LLNL in hazardous areas and on hazard-producing equipment to ensure worker protection.

Danger Signs shall be used to indicate imminently hazardous situations that, if not avoided, will result in death or serious injury. The signal word (refer to Appendix B) should be limited to the most extreme situations. Danger signs also shall be used for

asbestos work and for some radiological protection applications. (See Document 20.1 for information about signage for radiological protection.)

Warning signs shall be used to indicate a potentially hazardous situation which, if not avoided, could result in death or serious injury. These signs shall not be used for radiological protection. For this application, only danger or caution signs are allowed.

Caution Signs shall be used to indicate a potentially hazardous situation which, if not avoided, could result in minor or moderate injury.

Notice Signs are used to indicate a statement of organization policy that relates directly or indirectly to the safety of personnel or protection of property. The signal word shall not be associated with a hazard or hazardous situation that warrants a danger, warning, or caution sign.

General Safety Signs are used to give general instructions, such as safe work practices, reminders of proper safety procedures, and locations of safety equipment. General safety signs may have signal words such as "Safety First," "Safety Instructions," "Be Careful," or "Think." Other signal words that convey a general safety message are allowed. General safety signs shall not be associated with a hazard or hazardous situation that warrants a danger, warning, or caution sign.

Direction Signs are used to indicate exits, fire escapes, evacuation routes, stairways, first aid, etc. These signs shall meet the requirements of the Life Safety Code, NFPA 101.

New warning labels and signs should comply with the ANSI Z535 series of standards. Older signs and labels can be used until stock is depleted; thereafter, the new signs and labels are to be used. (This requirement does not apply to signs warning of radiological hazards or laser hazards, as current Work Smart Standards require the use of the new sign types, which are shown in Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials," , and Document 20.8 in the *ES&H Manual*, respectively.) For information about label formats and unique labeling situations, contact the area ES&H Team. Information about the layout and content of safety signs and labels for all purposes, other than radiological protection and lasers, can be found in Appendix B. Additional current references for sign standards and guidance are listed in Section 19.3 of this document. These should be taken as the US standard of good practice and used as specifications when purchasing, fabricating, or printing safety signs and labels for all situations other than radiological and laser hazards.

5.3 Signs for Specific Hazards

- Signs for radiological protection are specified in Document 20.1.

- Laser signs are a special case due to the "tailed sunburst" hazard warning logo. Requirements for laser signs and labels are given in Document 20.8.
- Warning logos and text for signs pertaining to nonionizing radiation and field hazards are given in Document 20.7.
- Signs for cancer-causing agents can be found in Document 14.12, "Safe Handling of Carcinogenic Materials," in the *ES&H Manual.*

5.4 Obtaining Signs

ES&H Teams can provide assistance with the type of sign needed. Standard industrial signs are available from commercial vendors. Signs for ionizing radiation, nonionizing radiation, lasers, and carcinogens, as well as some general safety signs are available from ES&H Teams. Metal or plastic signs for outdoor use may be custom-made in the Plant Engineering shops or purchased from commercial manufacturers. Custom-made signs shall conform to the criteria for each sign category; metal signs shall have rounded corners. Approval for safety signs is required prior to purchase. For specific approval authority, refer to the Procurement and Materiel controlled items list at the following Internet address:

http://www-r.llnl.gov/pm/trr/html/controlitem.html

6.0 Lights and Audible or Visual Warning Devices in Work Areas

The requirements in this section apply only to warning devices used for safety purposes; they do not apply to lights on consoles that indicate the status of equipment. (For information on remote status indicator lights see Section 7.0 Annunciation Devices for Remote Locations.)

Warning lights or audible warning devices are required for hazardous and highly hazardous operations, where they are needed to warn personnel against remaining in or entering a hazardous area. Building workers, and unescorted visitors, shall be instructed on the meaning of installed warning lights or audible warning devices and the action required when an alarm sounds. An explanatory sign shall be posted immediately adjacent to a warning device describing the hazardous condition and the actions required. In a highly illuminated area, it may be necessary to surround a light with a disk or wide-angled cone of a contrasting color to make the light more visible.

The following criteria apply to danger (red) or caution (yellow) warning lights installed to warn of a hazardous situation:

- Warning lights and accompanying signs identifying the hazard shall be on the final barrier workers would encounter when approaching the hazard.
- Warning lights shall reflect the status of equipment or hazardous condition inside of the barrier.
- Workers are not permitted access beyond an illuminated red warning light for routine operations. For specific, short-term activities, when access is an absolute necessity, a safety plan shall be written and approved by the authorizing organization. The safety plan shall describe planned activities in detail and designate individuals authorized to work beyond the danger warning light or sign.
- All warning lights shall be of the flashing, rotating, or oscillating type.
- Care should be taken to "size" the warning light to illuminate only the area of the hazard.

Table 2 lists various audible and visual warning devices, their meanings and use, and the actions required. Both visible and audible devices should be used, particularly in areas where sight- or hearing-impaired workers perform work.

A single display, driven by programmable logic using LED or other multi-color visible display technology, can be used to visually display different degrees of hazard.

Table 2. Audible and visual warning annunciators, their use, and required actions.

Warning device	General use	Action required
Red light	Danger	Do not enter.
Magenta or safety purple light (with or without chimes)	Danger—High radiation area	Do not enter.
Yellow light	Caution	Limit free access of workers and warn them to be on alert.
Green light	Area open	No entry restrictions.
Blue (or white) light	Notice	Condition requires response by responsible operating personnel.
Evacuation alarm, (klaxon sound, white strobe light)	Danger—Criticality accident or imminent high radiation hazard, toxic material release, large fire, etc.	Evacuate—Leave building or area immediately.
Air horn, steady	Danger–Fire in HE area	Take cover immediately; do not approach.

Chime, pulsed	Danger—High radiation or airborne radioactivity area (usually used with magenta light)	Do not enter.
Other sounds (bells, buzzers, etc.)	Warning—Hazardous condition exists	Be on alert; follow posted or announced directions.

Note: Lights listed are to be of the flashing, rotating, or oscillating type.

7.0 Annunciation Devices for Remote Locations

Annunciation devices for remotely located equipment and sensors shall be installed in occupied areas (e.g., control rooms or technician work areas) if the situation being announced is safety-critical, mission-critical, or life-threatening. Such devices also should be installed in occupied areas when a condition must be periodically monitored or logged or where the location of the sensor or device effectively rules out necessary ongoing monitoring of the annunciation. Annunciation devices shall be provided at the point of operation when the equipment user needs to be aware of the announced condition. Alarm annunciations shall continue until the device is manually reset. Fire Alarm annunciator locations are approved by the Fire Department.

8.0 Barricades and Barriers

The effectiveness of audible and visual warning devices is strongly influenced by many human factors (e.g., fatigue and distraction). To compensate for this, the use of physical barriers in conjunction with signs and warning devices shall be considered.

When choosing the type of barrier, consider the following:

- The nature of the hazard.
- The need for the barrier to be well constructed and durable, and to not interfere with the operation of the equipment or experiment.
- The circumstances under which the barrier can be opened or removed.
- Whether the barrier creates new or unacceptable hazards.
- The need for the barrier to prevent missile or fragment penetration and eliminate harmful overpressures associated with some hazards.
- The need for the barrier to serve as a shield to reduce radiation levels in occupied areas to acceptable levels.

Design engineers or experimenters shall ensure proper design, fabrication, assembly, installation, and testing of these barriers.

8.1 Open-Trench Barricades

Groups engaged in construction and maintenance work requiring open trenches or excavations shall provide protection for pedestrians, bicyclists, and vehicular traffic. Where possible, backfill the open trench/excavation immediately or provide a suitable continuous covering. If this is not possible, provide barricades to warn workers of the presence of the trench and its danger. Construction workers shall provide walkways adjacent to occupied buildings, main thoroughfares, intersections, and at recognized pedestrian traffic locations that can accommodate normal traffic patterns and emergency evacuation.

A construction barricade must meet the following criteria:

- Type II barricades (see definition), shall be positioned at 10-ft (3-m) intervals on each side of the trench. When viewed from the side, barriers on opposite sides of the trench shall not appear to be adjacent to each other but offset at 5-ft (1.5-m) intervals.
- Each barricade shall be placed at least 2 ft (0.6 m) away from the opening.
- Each barricade that will remain in place during periods of darkness shall be equipped with a 20-cm-diameter yellow flasher visible to oncoming vehicular and pedestrian traffic.
- When continuous solid barriers (e.g., fences) are not provided, tie interconnecting ropes or special yellow plastic strips (such as that available from Procurement and Materiel Stores Issues, stock no. 4280-65028) between the barricades (contact your ES&H Team for alternative materials). If ropes are used, attach streamers between the barricades.
- Crossing points shall be identified in construction drawings and sketches so that walkways and bridges with standard guardrails (or equivalent) can be provided. Furnish adequate lighting at the crossing points.
- Wherever vehicular traffic crosses a trench, install suitable metal-plate coverings for weight support.

8.2 Fences

A fence that is at least 4 ft (1.25 m) high can be used as a barrier. A barbed-wire top extension should be added to a chain link fence if it protects against a life-threatening hazard. Provide at least one vehicle gate that is at least 14 ft wide for each enclosure to permit entry of emergency vehicles.

8.3 Electrical Equipment Enclosures

For design and fabrication details, refer to Document 16.1 and Document 16.2, "Work and Design Controls for Electrical Equipment," in the *ES&H Manual*.

8.4 Locks

All doors, gates, or removable panels that permit entry through a barrier into a hazardous enclosure shall be locked or equipped with interlocks, or both, depending on the hazard, as determined during preparation of the IWS. Contact the lock specialist in the Safeguards and Security Department for assistance. The ES&H Team can provide guidance on the level of access control protection required.

9.0 Entry through Safety Barriers

Barriers are installed to prevent interaction of hazards and people. Workers shall pass through a barrier into an enclosure only at designated entry points and in the manner prescribed by posted instructions. Doors, gates, removable panels, and other places where entry is possible shall be secured, locked, or interlocked to prevent unauthorized entry and hazard exposure.

Where padlocks are used on entry points and duplicate keys are available, measures shall be taken to prevent a worker with a second key from being in the area unbeknown to the first worker. Where a lock-controlled master switch is installed in the interlock circuitry, the worker entering through the barrier shall retain possession of the solitary key and shall, upon leaving, verify that no one is locked inside. This key shall be the only key that can open the doors or gates into the enclosed area. Refer to Document 12.6, "LLNL Lockout/Tagout Program," in the *ES&H Manual* for additional information.

10.0 Securing Areas Controlled using Safety Barriers

Prior to operating hazard-producing equipment where personnel can walk in, the operator shall inspect all regions within the enclosed area of equipment protected by a barrier in an orderly manner (i.e., conduct a safety sweep). The purpose of this inspection is to ensure that no one remains in the area when interlocks and run/safe box chains are being made up, when the barrier is being secured, and when the equipment is being reactivated.

11.0 Interlock Systems

This section contains requirements and best management practices for designing and installing interlock systems. Additional requirements can be found in Document 20.8 for lasers and Document 20.3 for radiation-generating devices.

All interlock systems shall

- Be capable of automatically producing a safe condition when an interlock switch is interrupted.
- Have a basic emergency shutdown process.
- Have a formal design review.
- Be thoroughly tested and documented before initial operations, and regularly thereafter, in accordance with the controlling ES&H documents.

11.1 Specification Requirements and Recommendations

Automatic Safe Shutdown. Any breach of an interlock system shall result in the automatic safe shutdown of the system in the shortest time interval reasonably achievable and to an acceptable hazard level.

Fail-safe Operation. Components of interlock systems shall be selected to ensure that either power interruption or likely modes of component failure will most likely result in a safe shutdown of the system.

Start/Restart Considerations. Making up an interlock chain shall never, by itself, result in the startup or restart of a piece of equipment. Once an interlock chain has been interrupted for any reason, it shall be necessary to repeat the entire sequence required for making up the interlock chain.

Electrical Wiring. Interlock systems shall use low-voltage wiring, and all wiring shall be installed in conformance with the National Electric Code (NFPA-70). Where interlock wiring is bundled with other control wiring in the same cable or conduit, the other wiring shall not operate at voltages higher than that of the interlock wiring, and current shall be limited to preclude damage to the interlock conductors in case of a short circuit. To avoid creating secondary hazards, power interlocks with low voltage (i.e., 50 V ac or dc, or less) should be used, if possible.

Sectioning. Interlock systems that cover large areas or multiple facilities may be broken down into several sections. Breaking of the interlock chain for a section shall result in the automatic safe shutdown of that section. Sections shall cover appropriate areas, and

completion of the interlock chain for any section shall not activate a hazard in any section where the interlock chain is incomplete.

11.2 System Review

A review shall be conducted of new or modified interlock systems and documented. The documentation shall consist of approved schematics, wiring diagrams, drawings, and specifications, and logic analyses to ensure the system works as intended and complies with specified requirements.

A fault-tree analysis may be required for complex systems. For systems employing programmable controllers and computers, a review shall be conducted of the software and included in the configuration documentation.

A formal review shall be conducted of documentation and approved by the management level responsible for authorizing operations.

11.3 System Testing

Each safety function of any interlock system shall be tested on initial installation; whenever modification, repair, or maintenance that may affect the interlock system is complete; and when programmable controllers have been reprogrammed. In addition, each safety function of any interlock system shall be tested semiannually (every six months) unless otherwise specified in the controlling ES&H documentation. When the controlling ES&H documentation requires test procedures, the responsible individual ensures that appropriate procedures for the entire interlock system, consistent with the requirements in Document 3.4, "Preparation of Work Procedures," in the *ES&H Manual* are developed and followed. A written record shall be kept of each test conducted. Initial installation and testing shall be completed prior to approval by the authorizing individual.

11.4 Interlock Bypassing

Safety interlocks should only be bypassed to meet specific operational requirements (e.g., performing alignment, troubleshooting, and maintenance) and only under carefully controlled conditions.

Bypassing of interlock systems or modification to software for programmable controllers or computers that simulate bypassing interlocks shall be controlled by a written safety plan (e.g., Facility Safety Plans, FSP; or Operational Safety Plan, OSP) or other work procedures and an Integration Work Sheet. This documentation shall include the following information:

- Workers authorized to bypass interlocks.
- Level of supervision required during bypass operations.
- Muster provisions, as appropriate.
- Provisions for communicating information to workers in the area.
- Procedures for restoring interlock systems to full operation following removal of the bypass.

Other appropriate information (such as maintaining bypass logs) should be incorporated, as appropriate.

Routine bypass features may be provided for interlock systems for which access is limited only to qualified workers (e.g., bypass provisions at access doors to laser areas). In such instances, interlock bypass mechanisms shall be of the time-limited and self-resetting type. When routine bypassing is authorized, the interlock chain shall include circuitry to activate lights or other indicators at the console or master control to warn operators of the bypass condition, and the need to take necessary precautions. For nonroutine operations (e.g. troubleshooting), the interlock bypass condition shall be prominently identified at the console or master control and in the area where hazards exist. Interlocks for personnel safety must never be relied upon as the main means of discounting power sources (for additional information, refer to Document 12.6).

11.5 Typical Interlock System Components

The components listed below are required for complex interlock systems where serious injury or a fatality could result if workers were inadvertently left in the enclosure during operations (e.g., an accelerator cave where all areas are not visible from a single vantage point).

Master Control. The interlock system shall have a master control that monitors the interlock system, enables the equipment when the entire interlock chain is made up, and initiates automatic safe shutdown of the system when the interlock chain is broken. The master control shall be enabled with a lock-controlled master switch (LCM) or an equivalent device (e.g., a secure password for a computer-based system).

Status Indicators. At least one interlock-status indicator shall be provided at the console where the hazardous equipment or process is controlled. If workers could conceivably be left in an interlocked area, additional status indicators shall be provided and be clearly visible from all points within the area. Flashing lights, rotating beacons, and audible alarms may be needed to supplement status indicators in complex installations. Additional status indicators shall be installed at primary entrances to interlocked areas.

Lock-Controlled Master (LCM) Switch. An LCM switch or equivalent device is the final link in an interlock chain. Equipment cannot be energized unless the LCM switch has been turned on. The LCM switch shall not be capable of being turned on until all other interlock chain requirements have been satisfied. The LCM switch shall have only one key (or one set of keys, where multiple keys are required for machine actuation) that can only be removed when the switch is in the "off" position and the hazard has been deactivated. (This is sometimes referred to as a "captive key" system.) LCM switches shall not be bypassed and shall be wired so that they cannot be easily bypassed. Equivalent functionality may be obtained in a computer-based system using secure passwords.

Sweep Stations are required in large interlocked areas where workers could inadvertently be left inside. The following criteria apply to sweep stations in interlocked areas:

- Each sweep station shall be activated with the LCM key in a specified sequence, or within a specified time limit, when making up the interlock chain.
- Sweep stations shall be positioned within interlocked areas such that the sweeper tours the entire area, looking into every space where a worker might be present.
- Sweep stations shall not be bypassed by any remote or local means.
- Sweep procedures shall include audible alarms or broadcast of voice warnings, as appropriate.

Emergency Stop Buttons shall be conspicuously located in large interlocked areas where workers could conceivably be left inside. Newly installed units should have red mushroom-shaped buttons.

Status Control Stations. Status control stations typically have been designed to meet the criteria for three separate components: status indicator, emergency stop button, and LCM sweep station. Status control stations shall be used only inside the controlled area. Separate status indicators or area access control warning lights shall be used at entrances to the interlocked area.

Additional information about interlocks for specific types of equipment can be found in the following documents in Volume II of the *ES&H Manual*:

- For radiation-generating device (RGD) enclosures, see Document 20.3.
- For electrical areas, see Document 16.1.
- For laser areas, see Document 20.8.

12.0 Alarm Systems

An alarm system shall be used to alert workers if there is a potential or actual degradation in the safe working environment in a facility so that they can take appropriate action. Alarm systems respond to a change in ambient conditions (e.g., an increase in the radiation exposure rate, the presence of a combustible gas, or the presence of smoke). Examples of typical alarm systems are a constant air-monitoring system for radioactivity, a criticality alarm system, or a fire alarm system. Alarm systems shall notify workers of conditions in the immediate vicinity of the work area. Typically, they also provide notification remotely at the operations control console.

Alarm systems may be designed to initiate some additional actions such as shutting off the high voltage to an accelerator or x-ray machine, closing a fire barrier door, or alerting the Fire Department. The degree of sophistication and reliability of alarm systems shall be commensurate with the potential hazard involved.

Evacuation Alarm Systems. Onsite buildings and outdoor area shall be equipped with devices for notifying workers to leave the area, as required by Work Smart Standards (guidance can be obtained from ES&H Teams). An evacuation may be signaled by the continuous sounding of the LLNL standard alarm (klaxon sound) used to warn workers to evacuate the building immediately. Another method is the Emergency Voice Alarm (EVA) system.

In either case, workers shall immediately go to the prearranged assembly point or other locations as directed. The Responsible Individual, with concurrence of the ES&H Team, shall jointly determine the type of detection system needed. The extensiveness and reliability of the system shall be directly related to the magnitude of credible accidents that could occur from operations in or near the building.

13.0 Design Review and Documentation Requirements for Alarm Systems

The authorizing organization shall ensure that the appropriate design and software documentation is prepared for all alarm systems and modifications to such systems.

System drawings, specifications, and engineering calculations shall be prepared and reviewed in accordance with procedures established by the organization responsible for the system or work area (i.e., Electronics Engineering Department, Mechanical Engineering Department, or Plant Engineering Department Industrial Electronics Shop). The authorizing organization shall ensure that this documentation is maintained in accordance with the procedures in that organization.

Alarm system control software shall be reviewed and documented in accordance with a formal quality assurance procedure.

14.0 Testing, Inspection, and Maintenance Requirements for Alarm Systems

14.1 Testing

As part of the prestart review, performance verification tests shall be performed when a system is installed or modified. Testing shall be conducted semiannually thereafter, unless otherwise specified in controlling ES&H documents.

Required tests shall be conducted according to written test procedures that have been reviewed and approved by the authorizing organization or the appropriate management chain.

14.2 Inspections and Preventive Maintenance

Preventive maintenance and inspections shall be performed consistent with the controlling ES&H documents.

15.0 Software-Driven and Solid-State Devices

Programmable controllers are often used for personnel protective systems (e.g., interlocks for alarm systems). The software for these systems shall not be modified without approval of the authorizing organization or the appropriate management chain.

In addition, this type of equipment shall

- Be well characterized so that reliability, maintainability, and operability are known.
- Have redundant systems if it is necessary to continue operation for safety reasons in the event of a system or component failure.
- Have hard-wired feedback loops to indicate system irregularities.
- Operate in a manner such that activation of any safety sensor or the failure of critical systems or components will most likely result in a safe condition.

- Operate in a manner such that any temporary modifications to safety systems shall be cancelled when the system is placed in a start-up or power-available mode.
- Have password protection so that alterations can only be made by authorized personnel.

16.0 Access Control in Security Areas

When a potentially hazardous area is also a security area, the following criteria shall be met:

- A minimum number of entrances shall be provided for security areas. These entrances shall satisfy the requirements of NFPA 101 (Life Safety Code). Some exits may be provided for emergency use only.
- Entrances to and exits from security areas shall be equipped with doors, gates, rails, or other movable barriers that will direct and control the movement of workers or vehicles through designated portals.
- Panic hardware used on emergency exit doors in security area perimeters shall be operable only from the inside and shall be equipped with at least a loud local alarm. Door locks and latches shall comply with NFPA 101.
- All nonmonitored exits from protected areas, material access areas, or vital areas shall be equipped with intrusion alarms.
- Security controls shall not prevent rapid evacuation of personnel.

17.0 Responsibilities

General responsibilities for all workers are described in Document 2.1, "Laboratory and ES&H Policies, General Worker Responsibilities, and Integrated Safety Management," in the *ES&H Manual*. Specific responsibilities for access control systems, safety interlocks, and alarm systems are listed under each title.

17.1 Work Supervisors

- Ensure workers
  - — Are properly trained in the hazards and controls for the work assigned.
  - — Comply with the signals from audible and visual warning devices.

- Utilize barricades, barriers, fences, and other warning devices during construction and maintenance operations requiring open trenches or excavations.

17.2 Responsible Individual

- Ensure that appropriate access control and alarm systems are selected and implemented in activities where responsible.
- Assume responsibility for transient workers and visitors who enter areas subject to access control or alarm systems.
- Ensure that appropriate procedures for the entire interlock system, consistent with the requirements in Document 3.4 are developed and followed.
- Decide, with concurrence from the ES&H Team, the type of evacuation alarm system needed.

17.3 Workers

- Operate and maintain hazard-producing equipment, access control systems, and alarm systems in a safe manner.
- Comply with all signs and audible and visible warning devices.
- Only bypass an interlock or other safety system with proper authorization and required documentation (e.g., a safety plan).

17.4 Programs and Facility Management

- Obtain, install, maintain, and test alarms, barricades, barriers, interlock systems, signs, and other devices in accordance with this and other controlling ES&H documents.
- Develop and maintain required design and maintenance documentation for safety systems.

17.5 ES&H Team

- Provide or assist workers in obtaining the necessary safety signs.
- Inspect alarms, barricades, barriers, interlock systems, signs, and other devices in designated areas during routine walk-throughs of facilities.
- Assist authorizing organization and facility management in determining the appropriate access control and alarm systems for the area.

18.0 Work Smart Standards

10 CFR 835, "Occupational Radiation Protection."

10 CFR 850, "Chronic Beryllium Disease Prevention Program."

29 CFR 1910.269, "Electrical Power Transmission and Distribution."

29 CFR 1910, Subpart J, "General Environmental Controls."

29 CFR 1910, Subpart S, "Electrical."

29 CFR 1910, Subpart Z, "Toxic and Hazardous Substances."

29 CFR 1926, Subpart K, "Electrical."

29 CFR 1926, Subpart Z, "Toxic and Hazardous Substances."

DOE M 441.1, *DOE Explosives Safety Manual*.

DOE Order 430.1A, "Life Cycle Asset Management."

NFPA 70, "National Electrical Code."

NFPA 72, "National Fire Alarm Code."

NFPA 101, "Life Safety Code."

19.0 Resources for More Information

19.1 Contacts

For more information about access control systems, safety interlocks, and alarm systems contact the ES&H Team.

Contact the following individuals for operating procedures for access control systems and alarm systems:

- Responsible Individual
- Authorizing Individual

19.2 Lessons Learned

For lessons learned applicable to access control systems, safety interlocks, and alarm systems, refer to the following Internet address:

http://www.llnl.gov/es_and_h/lessons/lessons.shtml

19.3 Other Sources

29 CFR 1926, Subpart G, "Signs, Signals, and Barricades."

ANSI D6.1 Manual on Uniform Traffic Control Devices.

ASME A13.1-1996, "Scheme for the Identification of Piping Systems" (1991).

NEMA/ANSI Z535.2-1998, "American National Standard for Environmental and Facility Safety Signs and Labels" (1991).

NEMA/ANSI Z535.3-1998, "American National Standard for Criteria for Safety Symbols" (1991).

NEMA/ANSI Z535.4-1998, "American National Standard for Product Safety Signs" (1991).

NEMA/ANSI Z535.5-1998, "American National Standard for Accident Prevention Tags (for Temporary Hazards)" (1991).

NCRP Report 88, "Radiation Alarms and Access Control Systems" (1986).

Appendix A

Terms and Definitions

Access control system	An assembly of equipment and administrative procedures for controlling worker access to hazardous areas. Components of an access control system may include signs, lights, barriers, interlocks, run/safe boxes, and administrative control procedures.
Alarm system	A warning system to alert workers to the presence of an unexpected hazard or degradation in safe working environment, usually requiring immediate action.
Annunciation	A visible or audible cue that an alarm or warning device has been activated.
Area access control light panel	An LLNL term applied to various powered visual annunciator panels used to control worker access at the entrances to hazardous areas.
Barricade	A temporary structure set up across a route of access to deter passage of workers or vehicles. See definition of Type II Barricade below.
Barrier	A permanent physical device to protect workers from a hazard and control access to the area where the hazard exists (e.g., fences, machine guards, radiation shielding, blast barriers, and Faraday cages).
Beacon	A flashing or rotating light. Because of their nonspecific, wide area of coverage, beacons are primarily intended for use inside hazardous areas rather than outside.
Fail-safe	A system designed such that the loss of power or the failure of any component will most likely result in a safe condition.
Immediate evacuation alarm	A rapidly pulsing high-pitched tone that has replaced the Klaxon horn as the LLNL standard immediate evacuation alarm.

Interlock	A device that causes or prevents an action from occurring. The primary function of a safety interlock is to terminate a potentially serious hazard if a protective barrier is breached. Interlocks are classified into three main types: key-operated, mechanical, and electrical. A specific interlock, however, may involve more than one of the above types.
Interlock bypass	A means by which the function of an interlock is defeated.
Key interlock	An interlock that is enabled or disabled with a key.
Lock-controlled master switch	A key-operated interlock that prevents or enables the operation of the hazard producing equipment. The LCM is installed at the main control console for operating hazard-producing equipment.
Run/safe box	An interlock system component that houses a push-to-safe button and a sweep interlock switch. A push-to-safe switch prevents or terminates the operation of hazard-producing equipment.
Single-point failure	The loss of function or safety as a result of a single, credible event.
Sweep interlock	Interlocks that must be individually made up and are strategically placed in an enclosure to ensure that the area is completely searched before operation of hazard-producing equipment.
Status control unit	An improved version of the run/safe box. It includes a status indicator, a push-to-safe button, and a sweep interlock switch. (See run/safe box)
Type II Barricade, as required by ANSI Standard D6.1	A traffic control barricade that has the following features:

Minimum Height	3 feet
Width of Rail	8-12 inches
Length of Rail	2 ft minimum
Width of Stripes	6 in
Number of Reflectorized Rail Faces	4 (two in each direction)

Appendix B

Safety Warning Signs and Labels

Note: The safety warning signs and labels (Figures B-1 through B-4) in this appendix do not apply to radiological or laser hazards. Refer to Document 20.1 for posting requirements for radiological hazards and Document 20.8 for laser hazard posting requirements.

Safety signs and labels shall follow the format depicted in Figures B-1 and B-2. The three components of signs and labels are described below:

- A signal word that indicates the degree of hazard (e.g. caution, danger).
- A statement describing the type(s) of hazard(s). A visual logotype(s) (i.e., a graphic symbol) should also be used, especially for signs. Hazard-alert visuals should be placed in triangular-surrounding shapes, as shown in Figures B-3 and B-4. The background color should be yellow, and a black line should surround the triangle.
- A statement describing the actions to be taken. A visual logotype(s) should also be used. Recommended actions, such as a person wearing specified forms of personal protective equipment, should be shown in white against a blue circular surrounding shape. Prohibited actions should be noted using a red circle and bar covering a symbol describing the prohibited action, such as a lit cigarette.

The yellow, blue, and red background colors can be replaced by white, medium gray, and black or dark gray, respectively, for black and white printing. Black and white printing shall be done using a blank sign with the color scheme for the appropriate warning word, i.e., CAUTION, WARNING, or DANGER. A trial sign should always be printed and proofread for contrast and content before printing up signs to be posted. The use of colors and text should be carefully considered based on the hazards and the people to be warned about the hazard.

The background color of a DANGER sign is white. The signal word panel of a two- or three-panel sign is white against a red background immediately to the right of a white triangle surrounding a red exclamation point. The signal word shall be all upper case. On older signs, the signal word is white print in a red oval surrounded by a white stripe centered in a black rectangle.

The background color of a WARNING sign is white, if the signal word is displayed against an orange rectangle; otherwise the background color of a WARNING sign is orange. The signal word panel of a two- or three-panel sign is black against an orange background immediately to the right of a black triangle surrounding an orange

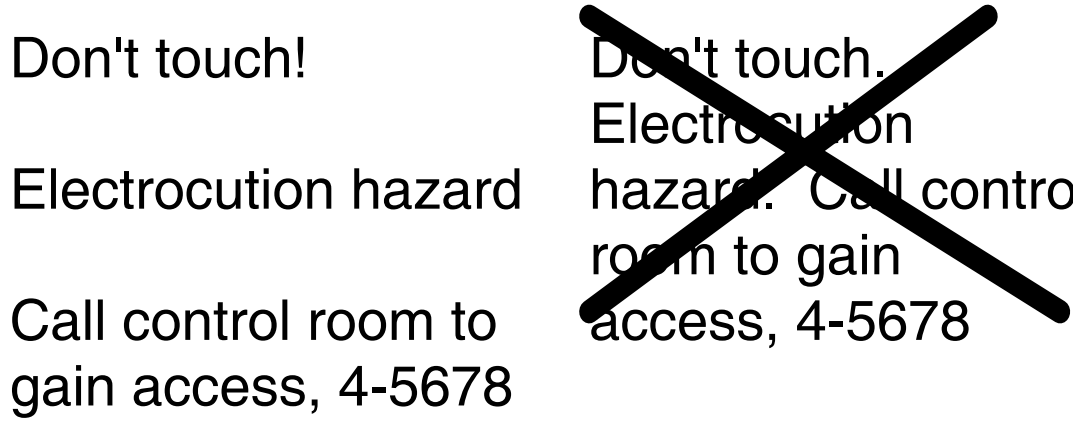
exclamation point. The signal word shall be all upper case. On older signs, the signal word is black print in an orange truncated diamond (hexagon) surrounded by a black rectangle.

The background color of a CAUTION sign is white, if the signal word is displayed against a yellow rectangle; otherwise it is yellow. The signal word panel of a two- or three-panel sign is black against a yellow background immediately to the right of a black triangle surrounding a yellow exclamation point. The signal word shall be all upper case. On older signs, the signal word is yellow print surrounded by a black rectangle.

The background color of a NOTICE sign is white. The advisory word panel of a two- or three-panel sign is in white print centered in a blue rectangle.

General safety signs may have signal words such as SAFETY FIRST, SAFETY INSTRUCTIONS, BE CAREFUL, or THINK in white letters against a green background. Other signal words that convey a general safety message are allowed. This type of sign must never be associated with a hazard or hazardous situation that warrants a DANGER, WARNING, or CAUTION sign. The background color of a general safety sign is white. The advisory word panel of a two- or three-panel sign is in white print centered in a green rectangle.

The text should usually begin by stating the action being sought (e.g., Keep out!) and follow with supporting information. However, there are exceptions. For example, the text of a DANGER sign could begin with the words "High voltage" followed by the words "Keep out!". Use the active voice (Keep out!) rather than the passive voice (You must not enter!). Use headline style information, omitting nonessential text. Include telephone numbers of people to contact in the text when appropriate. Left justify the text; do not center or justify both-sides. Use an outline format rather than a paragraph format, as shown below. Text bullets may be used in the outline format.



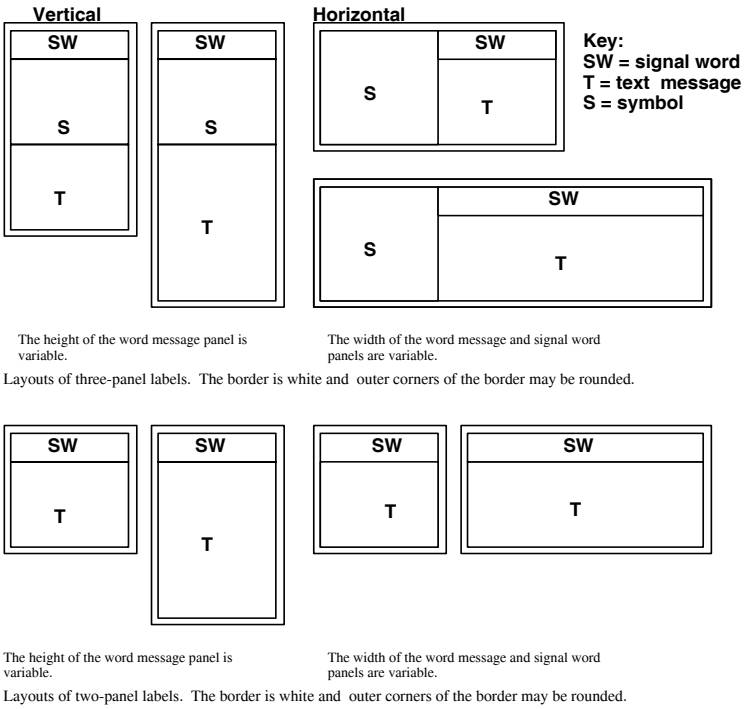


Figure B-1. Safety warning signs.

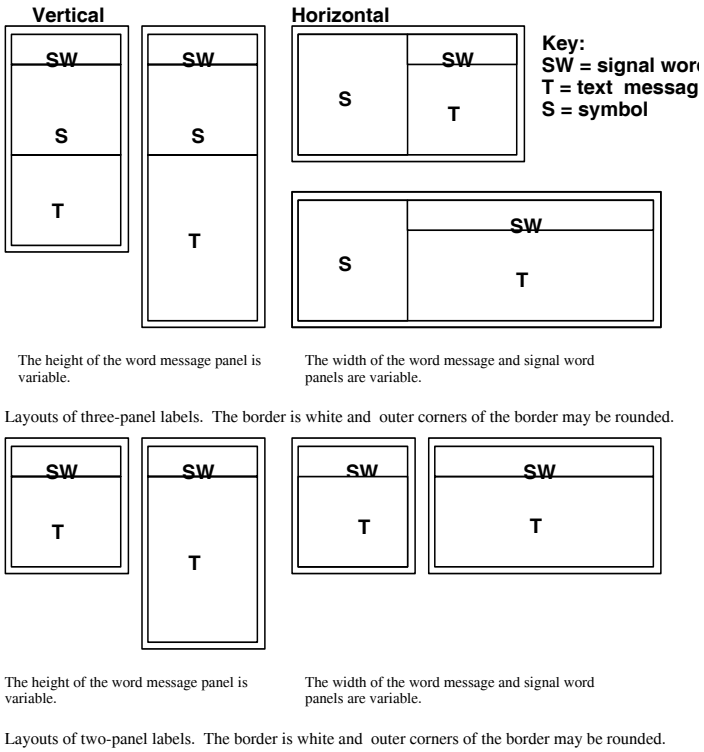


Figure B-2. Safety warning labels.

Figure B-3. Examples of signal word panels.

Figure B-4. Example of warning sign. Note that a symbol surrounded by a triangle denotes a hazard and a symbol including the circle and slash denotes a prohibited action. The desired actions precede the supporting information, and the text and symbols are completely separate (i.e., there is no wrap-around text).